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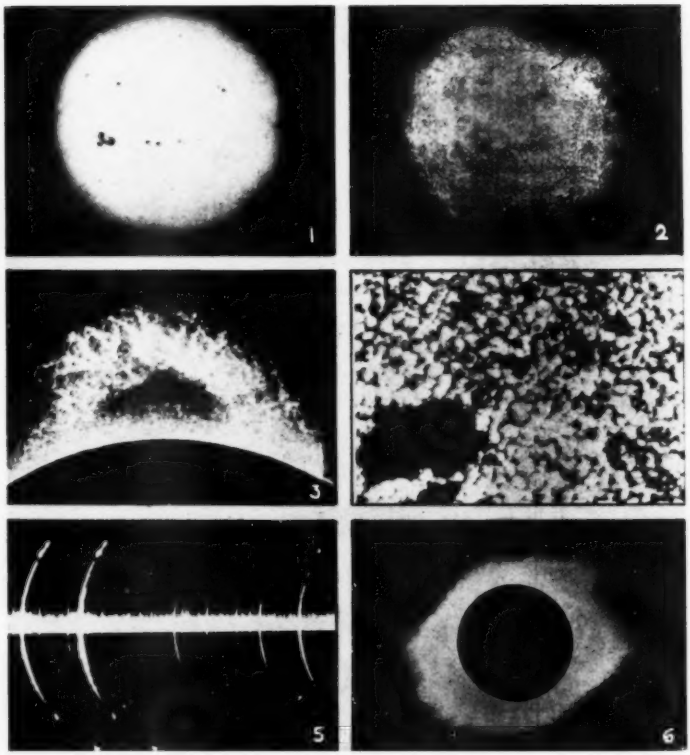
PLATE VIII



OBSERVATIONS OF SOLAR PHENOMENA

1. Direct photograph of the sun showing sun-spots and darkening at the limb, August 12, 1917. 1 and 2, Mount Wilson Observatory Slide B36.
2. Spectroheliogram in hydrogen Hα, showing flocculi; taken on the same date.
3. Eruptive prominence of June 4, 1946, taken $1^h 20^m$ before attaining record height. E. Pettit, *Pub. Ast. Soc. Pac.*, vol. 58, p. 310, 1946.
4. Photograph of solar granulation (greatly enlarged). J. Janssen, from *Astrophysica Norvegica*, vol. 4, p. 168, 1946.
5. Photograph of the flash spectrum at eclipse of August 30, 1905, showing arcs of ionized calcium (K and H) at left and hydrogen (Hδ) at right. S. A. Mitchell, *Astroph. Jour.*, vol. 71, p. 4, 1930.
6. The solar corona photographed at Yerbanis, Mexico, September 10, 1923, by the Sproul Observatory expedition. Miller and Marriott, *Astroph. Jour.*, vol. 61, p. 73, 1925.

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THE SUN—A TYPICAL STAR*

By K. O. WRIGHT

(With Plate VIII)

"WHAT is a star?" is a question very often asked members of this Society. We know it as a very distant, luminous body and, from its spectrum, we can obtain considerable information about its motion and the composition of its atmosphere. We know very little about the surface details of any star except one—our sun. However, it would appear to be a representative star, average in mass, luminosity and, perhaps, variability. During recent years there has been considerable research on the sun, its structure, radiation, and its effects on the earth and its atmosphere. In a lecture such as this it is impossible to cover the field completely but it is hoped to give a reasonably satisfactory review of our present-day knowledge of the sun.

We know that the sun appears as a luminous disk in the sky, 32 seconds of arc in diameter, which, by a strange coincidence, is almost precisely the same as the angle subtended by the moon. The Astronomer Royal, Sir Harold Spencer Jones, completed a study of the solar parallax in 1941 and found that, on the average, the earth is 93,004,000 miles from the sun. Thus, though it appears small to us, a simple calculation shows that the sun has a diameter of 865,400 miles—109 times that of the earth. It is responsible for effectively all the light and heat and, therefore, life, on earth; its energy is such that if used efficiently, it would generate 4,690,000

*A lecture given before the Victoria Centre, R.A.S.C., February 19, 1947.

horse-power per square mile of the earth's surface, and the light from each square inch of the sun's surface is equivalent to more than a quarter of a million candles. This means that the surface temperature is about 5710° K. This temperature must increase towards the centre and therefore the entire sun must be gaseous.

Direct observations of the sun, visual or photographic, show that its disk is not uniformly luminous. It is brightest at the centre; the intensity decreases outwards gradually, except at the very limb where it decreases rapidly so that the edge is only one-third as bright as the centre. This edge appears perfectly sharp but indentations of the order of thirty miles could not be distinguished at such a great distance. Detailed examination of the surface indicates that it has a mottled appearance, produced by granulations. More prominent at the present time are the sun-spots, for in 1947 we are approaching a period of sun-spot maximum. Near the spots, though more prominent when they approach the limb, there may be a few faculae, which are bright portions of the solar disk.

At a total eclipse of the sun other features of its atmosphere can be seen: deep red prominences, bright against the darker background of the sky at the limb, and, far beyond, the corona. The inner corona extends about 100,000 miles beyond the edge of the sun as a bright ring with a yellowish tinge; the outer corona, which can be seen for a distance of many solar radii, is pearly white in appearance and shows faint filaments, or rays, which vary in position from one eclipse to another.

These features can be seen directly under favourable circumstances. However, a great deal more information can be obtained from spectrographic observations. If the image of the sun is focussed on a narrow slit, beyond which is a prism and then a camera, a photograph of the solar spectrum may be obtained for study. It is found to consist of a continuous background of colour, the intensity distribution of which is similar to that produced by an incandescent body at a temperature of about 6000°. Upon this coloured band are superposed many thousands of dark absorption lines. Kirchhoff's laws tell us that the latter could be produced by an atmosphere containing many of the elements which we know on earth, which is cooler than the main portion of the sun but which is hot enough to

vaporize all known materials. For many years it was thought that there was a definite layer in the sun, the photosphere, which formed the continuous spectrum and above it lay the reversing layer, whose constituents produced the absorption lines. However, now it seems that the layers which produce the continuous and the line spectrum cannot be completely separated but gradually merge one into the other.

Identification of the absorption lines shows that most terrestrial elements are present in the solar atmosphere. Indeed, although some have not yet been identified as present in the sun's spectrum, the most probable reason for this lack is that there are no strong lines in the spectrum of such an element in the range of wave-lengths accessible to us. The recent successful photography of the solar spectrum from λλ2300-3000 angstroms—a region which is normally cut off by the ozone layer in our atmosphere—from a V2 rocket suggests that positive identification of other elements in the sun's atmosphere may be possible in the near future.

A glance at the solar spectrum shows that some lines are much broader than others and detailed studies of these lines, particularly the red hydrogen Hα line and the violet H and K lines of ionized calcium, give further information concerning the structure of the solar atmosphere. The chief instrument used for this purpose is the spectroheliograph, which was invented by G. E. Hale, that great pioneer in solar physics. He used a powerful spectrograph but inserted a second slit immediately in front of the photographic plate and thus photographed only a very minute portion of the spectrum. By causing the image of the sun to drift slowly across the first slit and the photographic plate to move at the same rate past the second slit, a picture of the whole solar disk at the desired wave-length was built up. These spectroheliograms may be quite different in appearance from direct photographs of the solar disk. Those taken in the light of the outer parts of the strong lines are similar to direct photographs and show sun-spots and faculae. Nearer the centre of a line a spectroheliogram shows that the bright regions of faculae surrounding a spot appear strengthened both at the limb and at the centre of the disk. In the light of the very centre of a line these flocculi, as they are now called, frequently cover not only the penumbra but also the umbra of a spot. There, in addition to bright

flocculi, dark structures extend over the surface "like gigantic worms" which, when observed at the limb, are recognized as prominences in absorption. Theory as well as observation shows that photographs made in the wing of a line represent the lower levels of the atmosphere; those at the centre of a line indicate the structure of the upper regions.

Having noted the importance of the spectrograph in the study of solar phenomena, let us return to the several solar phenomena and describe briefly the observational data and the current explanation of their cause and the level in the atmosphere at which they originate.

SUN-SPOTS. Sun-spots were discovered telescopically by Galileo in 1610 and have been studied more or less systematically ever since. They consist of a dark umbra ranging from 500 to 50,000 miles in diameter and a surrounding penumbra which may be as much as 150,000 miles across. Though the spot appears dark in contrast to the rest of the sun, it is nevertheless very bright and hot, being only a few hundred degrees cooler than the surroundings. The periodicity of the sun-spot cycle was discovered by Schwabe in 1843; Newcomb found that the average time from sun-spot maximum to maximum was 11.13 years, but this value has varied from 7.3 to 17.1 years. The spot activity for a given year is represented by a number which was defined by Wolf in 1848 and represents approximately the area of the sun's surface covered by spots in that year. Many efforts have been made to relate the observed variation of the solar cycle by superposing cycles of different period but it seems certain that no such harmonic analysis will be successful. The cause of the distrubances is deep-seated and not rigorously periodic. Another feature of sun-spot activity which must be explained by any theory is the so-called "butterfly diagram" studied by Maunder. He plotted the heliographic latitude of each spot against time, which readily explains the origin of the name. He found that at the beginning of a cycle the spots appear about heliographic latitudes $\pm 40°$. As the activity increases they show up in lower latitudes and by the end of the cycle most of the spots occur near latitudes $\pm 5°$, though the next cycle seems to begin with spots at high latitudes before the previous one ends. That very few spots

appear in latitudes higher than 40° is another phenomenon which requires explanation.

Sun-spots tend to occur in pairs or groups. Many last less than a day but about one in fourteen lasts long enough to appear a second time on the solar disk. Though the period of rotation of the sun can be determined directly from the Doppler shift of spectral lines at the limbs, sun-spots give a second method of deriving it. It is found that the period is less at the equator ($24^d.6$) than at higher latitudes ($25^d.8$ at 30° and $27^d.5$ at 40°), though there is some individual motion of the spots themselves. The latter tends to be irregular however. Small spots move more rapidly than large ones and the leading spot has a greater motion than the following spot. Though the position on the sun where spots occur tends to approach the equator during a cycle, the motion of individual spots is somewhat at random; on the average, the motion in longitude is about 5400 miles a day while that in latitude is only 3000 miles. The preceding spot is usually more regular and more compact than the following spot and almost invariably has a magnetic field associated with it, the polarity of which is opposite to that of the trailing spot. This observation, which was discovered by Hale from the Zeeman splitting of spectrum lines, seems to be fundamental, for spots change polarity in succeeding cycles and the leading spots in different hemispheres have opposite polarity.

The appearance of a spot suggests that it is a mass of gas in motion and that the transfer of energy is by convection, as in the earth's atmosphere. However, Minnaert and Wanders made a study of the problem and found that the distribution of energy in sun-spots and the law of limb darkening did not agree with observation on the basis of a convection theory. On the other hand, the theory of radiative equilibrium, which is found to apply to the upper layers of the sun in general, holds also for sun-spots. As they are cooler than their surroundings, however, they must be unstable—but this observation is merely in agreement with the fact that they have a finite lifetime. Many attempts have been made to present a comprehensive theory to explain sun-spots and the cycle of solar activity. Hale suggested that the two components of a bi-polar spot are connected by a U-shaped vortex. The free ends would act as pumps to force the gases upward and cause their

cooling by adiabatic expansion and their polarity would be related to the opposite sense of their rotation. Bjerknes extended this theory, since spots probably arise from some deep-seated disturbance below the surface, by considering that a vortical current wound round the sun like a snake and that the spots appeared where the current broke through to the surface.

Many others have attempted to explain the solar cycle and several theories are currently being examined. A mathematical treatment of the problem which claims to explain most of the hydrodynamics of the solar atmosphere has just come to hand. Though I cannot vouch for the details and though the mathematics is certainly far beyond an address of this nature, a brief reference to this theory may not be out of place. J. Wasiutynski, a Pole who spent the war years at the Institute for Theoretical Physics in Oslo, considers that the solar activity can be explained on the basis of turbulent motions in the atmosphere, where turbulence is defined as rapidly changing fluid motion, the result of non-stationary vortices on the mean hydrodynamical field. He finds that sun-spots are traces at the level of the photosphere of deep-seated eddies produced not by circulatory pumping action but by their magnetic fields.

Wasiutynski lists several observational characteristics which are not explained by Bjerknes' theory of sun-spots: Certain asymmetries in the components of a spot—the leader is more compact, lasts longer and has greater proper motion; the ascending branch of the sun-spot curve is steeper than the descending one; sun-spots do not exhibit vortex motions at the level of the photosphere; and they do not possess a slow motion in the direction of the equator corresponding to the motion of the sun-spot belt. His own explanation for the cycle of activity is that it is due to non-uniform rotation of a gravitationally stable layer in the sun. A rotational shearing force is built up in middle latitudes by convection currents. Following this force, turbulence is set up at the beginning of a cycle which smooths out the shearing force in the mean latitudes but, as instability is built up in adjoining belts, this wave of turbulent motion proceeds towards the equator, thus producing the effect of a moving zone of spots. (A weaker wave of turbulence proceeds towards the pole, as evidenced by a zone of high-latitude promin-

ences.) On this basis the characteristics of sun-spots are explained and the peculiarities of the curve obtained when Wolf sun-spot numbers are plotted against time. The magnetic field of a large eddy gives rise to a spot at the level of the photosphere. The reversal of polarity in successive cycles is explained as due to the fact that a new cycle starts at high latitudes before the previous one has completely died away and there is a strong tendency for the direction of rotation of the eddies to be reversed.

FACULAE. As noted before, faculae are those bright regions on the sun's surface which appear in approximately the same zones as spots, which frequently arise before a spot is formed and continue after it has disappeared. Although the zones of faculae do move with the sun-spot belts in general and although there is a weaker zone in high latitudes, Wasiutynski considers that they are not completely related because Strebel finds differences in the two distributions over the solar surface. As the faculae are at a temperature about one hundred degrees hotter than their surroundings, he suggests that there is a super-adiabatic temperature gradient produced in a layer, which seems to be outside the spot layer and could, perhaps, arise from ionization of helium.

GRANULES. Granulation of the solar surface has been known for a long time but there has been considerable controversy about the size and lifetime of granules. Many of the best photographs were obtained by Janssen in 1872 using a small three-inch telescope and "wet" plates. He observed that the individual granules are roughly circular (they are now considered polygonal). He also discovered the presence of a photospheric "net"—a secondary phenomenon where "strings of beads" seem to appear as if the granular structure were almost obliterated by a violent current. Wasiutynski suggests that Janssen's photospheric net is a real phenomenon, though some observers have suggested that the blurring is due to disturbances in the earth's atmosphere. The long chains of granules, frequently called "willow leaves" in contrast to the "rice grains" of individual granules, show the existence of powerful streamings in this layer which are produced by a deep-seated circulation.

Statistical studies indicate that a granule is about 5″ in diameter—a distance of 2200 miles on the sun's surface—and its lifetime is about five minutes. As they change so rapidly, even early observers suggested that they are associated with powerful currents. The modern view, due to Unsöld, is that they are convection currents. Owing to ionization of hydrogen, the equilibrium of this layer is unstable. There is an ascending mass of gas which, heated by the energy released from captured electrons, becomes hotter than the surroundings.

The granular polygons have been associated with laboratory experiments performed by Bénard. He observed that currents in thin fluid layers produce a network of vortex rings in a polygonal cellular structure. Rayleigh discussed the theory of this phenomenon and, on the basis of his interpretation, solar granulation arises from a layer about 500 miles thick.

THE CHROMOSPHERE. The chromosphere may be considered one portion of the upper atmosphere of the sun. It is the region which produces the bright arcs of the flash spectrum observed at solar eclipses. The fact that these arcs vary from very short ones corresponding to weak lines in the Fraunhofer spectrum to great long arcs for the hydrogen lines and the H and K lines of ionized calcium was formerly explained as a result of considerable stratification in the chromosphere and the length of the arcs was taken as a measure of the "height" of the different elements in the atmosphere. Wildt's recent analysis of Mitchell's "heights" indicates that the relative abundance of metals in the chromosphere is similar to that in the Fraunhofer absorption spectrum, but the ratio of the abundance of hydrogen to the metals increases greatly with height.

Spectroheliograms taken near and at the centre of strong lines in the Fraunhofer spectrum show conditions at various levels of the chromosphere. The flocculi appearing on such plates show great similarities to granulations on direct photographs. They are most conspicuous at the middle and high levels for calcium and, as observed by Deslandres, form a "chromospheric net" where the bright flocculi form along the sides of polygons about 1′ in diameter, and these have dark interiors. Radial velocities of the order of 2 km./sec. are indicated, with the bright flocculi moving downwards and the

darker areas moving up. For hydrogen there seems to be a net of dark flocculi but they are somewhat obscured by a general granular structure of the chromospheric layer. As these granules are considerably larger than those of the photosphere, it is difficult to explain them on the basis of a similar circulatory system, but the effect of radiation pressure must be considered here. In addition, there are also very small granules, bright in the case of calcium flocculi and dark for hydrogen which Hale and Ellerman consider as rising columns of gas related to the slender filaments seen in the spectrograph at the limb of the sun.

Unsöld considers that the chromosphere is a field of prominences since direct photographs show that it is not a uniform gaseous layer. Turbulent motions within the chromosphere have been studied by measuring the widths of emission lines in the flash spectrum and it has been shown that the latter are considerably broader than the lines in the absorption spectrum where there is little turbulence. All investigations indicate velocities of about 10 miles per second which Unsöld explains as the sum of the motions of the small prominences which produce the images on the spectrograph slit. It seems that radiation pressure is important in the production of these motions. Milne developed a theory which called for the support of the calcium chromosphere by radiation pressure, which was just sufficient to maintain the ionized calcium atoms. However, it seems that there are many calcium atoms present for every one which produces the great H and K lines; therefore, the theory, which does not wholly agree with observation in any case, must be modified. A theory combining features of an existing radiation pressure and also the observed velocity distribution seems called for, and the proposed identification of the chromosphere with prominences seems highly plausible.

PROMINENCES. The study of the types and motions of prominences is a most interesting one but here we can only summarize a few of the results that have been obtained. Much of the work on their observation and classification has been done by Pettit, who divides them into six classes:

1. active—a mass of crossed and interlacing filaments in which brighter fragments can be seen;

2. eruptive—which rise quickly and almost vertically and then fade away;
3. spot—like the beams of a fountain, near sun-spots;
4. tornado—twisted columns which appear like a vortical spiral;
5. quiescent—which have no external streamers and change very slowly;
6. coronal—which form above the solar surface and rain down upon it.

Prominences were first described from visual observations of the total eclipse of 1868 as bright red projections above the limb of the sun, but almost immediately afterwards they were observed outside of eclipse by looking at the Hα line in a spectroscope using a wide slit. Further information concerning prominences can now be obtained from spectroheliograms, where they may also appear on the disk, usually at the limb, as either long dark absorption filaments or bright hydrogen flocculi.

As an example of the shape of a prominence, consider the eruptive prominence of record height, June 4, 1946, which was studied by Pettit. It developed from May 10 to 23, at which time it was a mass of interlacing streamers of coarse structure; on June 1 it appeared as a broad arch in eruption, 6200 miles thick, 70,000 miles broad and 300,000 miles high. On June 2 it extended through ninety degrees of longitude and on June 4 it expanded rapidly and reached the record height of 1,060,000 miles—more than one diameter above the sun.

Knowledge concerning the motions of prominences was increased greatly when the staff at the McMath-Hulbert Observatory were able to apply the motion-picture technique to obtain multiple exposures in rapid succession. From photographs taken there and at Mount Wilson Observatory, Pettit discovered two laws: (1) the velocity of an eruptive prominence remains generally constant, but may receive sudden accelerations which may repeat themselves after several minutes or hours; and (2) these impulses are always integral multiples of a certain value, though the fundamental impulse may vary for different prominences.

From observations of spectroheliograms, Newton found that a bright hydrogen flocculus may be the origin of a prominence, or may set a quiescent prominence into motion by some repulsive force. On the other hand, sun-spots seem to attract neighbouring prominences. They approach the spot almost horizontally with speeds of about 30 miles per second and then the head of the prominence

turns downward sharply and is engulfed in the penumbra, at which time a dark spot appears on the spectroheliogram.

The force which causes prominences to leave the sun's surface has been considered as due to radiation pressure. Unsöld studied this effect for hydrogen and came to the conclusion that there is a great excess of short-wave radiation in the Lyman continuum, about 800 A., which provides sufficient pressure to drive a prominence upward. The fact that this excess radiation is about a million times greater than that expected for a black body at the temperature of the sun seemed unbelievable at first. However, there have been many indications that there is a large excess of short wave-length radiation in the solar spectrum. Magnetic storms and aurorae appear about twenty-six hours after solar eruptions, which indicate that they are produced by matter ejected from the sun at velocities of about 1000 miles per second. At the present time there is great activity in the field of solar research and its relation to radio fade-outs and changes in the Heaviside layer in our atmosphere. These suggest sudden large increases in the radiation at the solar surface by a factor of about one to five thousand. Hence the theory that these disturbances are produced by prominences which reach the earth must be considered possible.

THE CORONA. The corona extends to a very great height above the sun but formerly was visible only for a short time during solar eclipses. A few years ago Lyot, who addressed a meeting of this Centre last year, constructed the coronagraph which, by cutting down scattered light, permits observation of the corona in full daylight. Though there are only three coronagraphs in operation at present—the nearest being at the Harvard Station at Climax, Colorado—the greatly increased opportunities for the observation of the corona may permit a more speedy solution of the many problems relating to it.

That the corona is affected by the cycle of solar activity is shown by the fact that it appears somewhat flattened at sun-spot minimum and more symmetrical with polar rays at maximum. Other relations have not yet been proven, probably a result of the scarcity of observations.

Much of the research conducted on the solar corona has been in

connection with the decrease in brightness outwards from the limb of the sun, and the polarization of its light. The former falls off very rapidly in the inner corona, inversely as the 17th power of the distance from the limb; in the outer corona the decrease is less rapid, being inversely as the 2.5th power of the distance, according to Baumbach. The polarization of the light increases with distance from the limb according to most measurements. Both of these observations fit the hypothesis that photospheric radiation is scattered by free electrons at considerable distance from the sun but, in addition, there would seem to be unpolarized thermal emission or weakly-polarized scattering by larger particles.

The spectrum of the corona also varies with height. Up to 10′ from the limb it is almost entirely continuous; above this region the recently-identified coronal emission lines appear and at greater heights there reappears the familiar Fraunhofer absorption spectrum, which is produced undoubtedly by scattering, though it may not be due entirely to electrons.

The identification of the coronal lines by Edlén of Upsala as arising from transitions within highly-excited atoms is a triumph of modern theoretical spectroscopy. Edlén has obtained laboratory spectra of atoms which had been stripped of several of their planetary electrons by means of very high-voltage discharges. By extrapolating from this known behaviour to prediction of the spectra of more highly ionized atoms, he was able to show almost conclusively that several lines in the corona are produced by atoms of iron with thirteen electrons missing (Fe XIV), and that other lines are produced under similar conditions by highly-ionized atoms of calcium, argon and nickel.

If the corona were in thermal equilibrium a temperature of about a million degrees would be required to produce conditions under which these lines could be formed. Previous studies by Menzel and Goldberg concerning the great width of the lines had suggested temperatures of this order. As the surface temperature of the sun is only about six thousand degrees it is difficult to explain conditions in the corona except on the assumption that there is a very intense radiation in some other portion of the spectrum; we have noted already that other lines of inquiry suggest that this is in the Lyman region of very short wave-length. Thus, as Unsöld has pointed out,

conditions in the corona may be an extreme case of those in the upper chromosphere and in quiescent prominences.

Menzel has suggested that this excess radiation might be ejected from the interior of the sun through holes or cracks in the surface. On the other hand, Saha has put forward the hypothesis that conditions of such high excitation might be produced by some kind of nuclear fission, somewhat similar to that of uranium which has been so widely publicized since the explosion of the atomic bomb.

THE INTERIOR OF THE SUN. Since nuclear fission has been discussed so much recently, we should not close our talk this evening without a brief mention of the source of solar energy. Until 1939 no satisfactory hypothesis had been put forward to explain the enormous output of solar energy, though Einstein's relation that $E = m c^2$, i.e., that energy could be produced by the annihilation of matter, seemed a possibility. At that time, Bethe considered all known and possible reactions between atomic nuclei and the elementary particles—electron, positron, proton, neutron, etc.—and came to the conclusion that if a temperature of twenty million degrees could be postulated for the central portion of the sun, then a cycle which, in effect, changed four atoms of hydrogen into one atom of helium could produce the energy observed at the surface of the sun. Carbon and nitrogen enter into these reactions as catalysts but are not changed during the process. Since both hydrogen and helium are very abundant elements, the possibility that these reactions might be important in explaining the solar energy was considered immediately. Bethe assumed that about one per cent. of material in the sun is carbon and, from the calculated lifetime of the products in the reactions, considered that the cycle would be completed in five million years. With these and other reasonable assumptions and the use of Einstein's equation, Bethe was able to relate the calculated energy output of the sun to that observed by Abbot and others.

It might seem that a temperature of twenty million degrees for the centre of the sun is excessive. However, if it is assumed that the pressure of each point within the star is such that it can support the weight of all overlying layers, then the central pressure in the sun must be at least 5×10^8 atmospheres. Further, since stellar

matter behaves as a perfect gas even at the surface temperatures of the sun, application of the gas laws shows that the central temperature must be at least two million degrees. Numerous stellar models, calculated for possible distributions of mass, temperature, pressure and composition have been studied and they all agree that the central temperature assumed by Bethe is reasonable for the sun.

This then, is the picture of the sun as we know it to-day. More complete explanations of some of the phenomena may be given within the next few years but, for the most part, we feel that we understand a little of what is taking place in our nearest star. Conditions are different in supergiants and in white dwarfs but when observations of stellar phenomena require a model, our sun may be taken as a first approximation to the conditions in other stars.

Dominion Astrophysical Observatory,
May, 1947.

WAVE-LENGTH STANDARDS FOR RADIAL-VELOCITY DETERMINATIONS, II* THE "A" STARS WITH HIGH DISPERSION

By R. M. Petrie

ABSTRACT

Effective wave-lengths for radial-velocity determinations are derived from ninety-two spectrograms of seventeen A-type stars. The system is that of the solar-type wave-lengths previously determined and is coordinated with them through the media of the Taurus, Coma, and Ursa Major Clusters and certain visual binaries. The radial velocities of fifteen stars are given as a result of the investigation.

The methods adopted for a revision of the Victoria system of radial velocities have been described in some detail in a previous Contribution.[1] This paper extends the revision to the A-type spectra observed with high dispersion similar to that employed in three-prism instruments used for precise radial-velocity determinations. The aim is to establish the velocities of all spectral types upon a common dynamical basis founded upon the velocities of objects in the solar system. To this end it was proposed to make use of observations of stars belonging to moving clusters and also to employ observations of visual binaries, one component being a solar-type star. The cluster motion may be found from radial-velocity observations of the solar-type members and this applied to observations of the A-type members will give a control so that the wave-length systems will be consistent. Similar considerations apply to the visual binaries used as control objects. A further independent control may be applied if a cluster is close enough, when observations of the parallaxes and proper motions of the member stars permit the determination of its space motion independent of radial-velocity data.

The objects used in the investigation of wave-length standards for class A spectra, embracing the types A0 to F2 inclusive, are the Taurus, Coma and Ursa Major clusters and the visual binaries A.D.S. 5559, 9626 and 15600. The space motion of the Ursa Major

*Contributions from the Dominion Astrophysical Observatory, No. 10.

[1] *Cont. Dom. Ap. O.*, no. 4, 1946: *J.R.A.S.C.*, vol. 40, p. 325, 1946.

cluster may be calculated from the parallaxes and proper motions of the nearer members as demonstrated by Smart.[2] Following him a value 19.1 km./sec. is adopted for the cluster velocity relative to the sun, from which the expected radial velocities of the member stars may be computed. The velocity of the Taurus cluster has been computed from high-dispersion radial velocities of the stars γ, δ, ϵ and θ^1 *Tauri*. The determinations at the Lick Observatory[3] and with the high dispersion spectra at Victoria have been used here since both systems are corrected to the solar system velocities. For the Taurus cluster the space motion, relative to the sun, is found to be 43.1 $\pm$0.2 and this has been adopted. The Coma cluster has been studied in detail by Trumpler[4] and his value -0.4 km./sec. has been adopted as the radial velocity of the cluster. The radial velocities of the solar-type components of the visual binaries were taken from the Lick III-prism and Victoria high-dispersion determinations.

The A-type stars measured for wave-length determinations and used as controls are as follows: in the Taurus cluster, H.D. Nos. 25570, 27934, 27962, and 28546; in the Ursa Major cluster, H.D. Nos. 40183, 48915, 118022, and 222603; and in the Coma cluster H.D. Nos. 107966, 108382, and 108662. The bright A stars in the direction of Ursa Major were not included since their observed radial velocities are known to deviate rather strikingly from that computed from the above cluster motion. Until the phenomenon is better understood it seemed preferable to omit these stars. Eighty-three spectrograms of fourteen control stars were measured in detail for effective wave-lengths; the spectral types range from A0 to F2.

The spectrograms were measured in the conventional manner, direct and reversed, upon the projection micrometer. Some fifty lines were measured in the initial list from which the final selection was made. The residual, for each line, from the adopted control velocity was found and mean residuals line by line were plotted against spectral type. It was then seen which features varied in wave-length over the spectral-type range and could be eliminated.

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[2] *M.N.*, vol. 99, p. 445, 1939.
[3] *P. Lick O.*, vol. 18, 1932.
[4] *Lick O.B.*, no. 494, 1938.

The remaining features were then studied individually in order that the proper wave-length of the line or blend could be deduced.

The A stars are probably the most difficult and recalcitrant of the spectral divisions in studies of this sort. The excitation is ordinarily low enough to allow of the appearance of a great many lines of the neutral and ionized metals, and consequently nearly every spectral feature is a blend of two or more spectral lines. The treatment of this aspect of the problem is complicated by the great variations of line sharpness encountered in the A stars, no doubt due to stellar rotation. On the other hand the excitation is higher than that prevailing in the solar atmosphere and hence the *Rowland Map* and *Table* are less reliable guides than in the later types. An additional difficulty is the great variety of spectra included in class A, the occurrence of "strontium" stars and "rare earth" stars being noteworthy in this connection.

To preserve homogeneity and continuity with the solar-type spectra it was decided to employ solar wave-lengths rather than laboratory values. It is well established that a difference exists between the two systems, presumably caused by physical conditions in the solar atmosphere. The same causes no doubt are operative in stellar atmospheres so that solar wave-lengths should be appropriate for determining the radial velocities of the A stars as well as those of types F to K.

The *Revised Rowland Table* was hence the source of the wave-lengths while the required information about the relative intensities of the blending lines of a feature was taken from high-dispersion studies of *Sirius*,[5] *γ Geminorum*,[5] *β Coronae Borealis*,[6] and *Procyon*.[7] The *Revised Multiplet Table*[8] was consulted also in the majority of cases.

The effective stellar wave-lengths were determined by the method adopted in the previous work,[1] each feature being studied as an independent unit. The wave-lengths of the separate lines contributing to a blend were taken from the Solar Table. The relative intensities as estimated in the spectra of the A stars mentioned

[5]Aller, *Ap. J.*, vol. 96, p. 321, 1942.
[6]Hiltner, *Ap. J.*, vol. 102, p. 438, 1945.
[7]Swensson, *Ap. J.*, vol. 103, p. 207, 1946.
[8]Miss Moore, *Cont. Princ. O.*, no. 20, 1945.

above were then used as weighting factors to predict the mean wave-length of the blended feature. It is emphasized that the wave-lengths were predicted from the high-dispersion spectra and the control-star velocities were used in general only to verify that the prediction was successful. No attempt was made to force each feature to reproduce exactly the adopted stellar velocity since this would incorporate in the wave-lengths the residual errors of measurement and any systematic errors introduced by the spectrograph, etc. In general, if the effective wave-length could not be predicted successfully from the high-dispersion data, the feature was rejected as a velocity standard. One or two exceptions were permitted for

TABLE I. EFFECTIVE WAVE-LENGTHS FOR RADIAL-VELOCITY DETERMINATIONS OF CLASS A STARS

λ I.A.		Valid Spectral Interval	Identification
3933.640	*a*	A0 – F0	Ca II
68.494	⊙	A0 – A2	Ca II
4030.653	⊙, *	A5 – F2	Mn I, Fe I, Ti I
45.804	*a*	A0 – F2	Fe I, bl.
63.564	⊙, *	"	Fe I, bl.
71.698	⊙, *	"	Fe I, bl.
77.652	⊙, *	A0	Sr II, Cr II, La II
4101.787	*a*	A0 – F2	Hδ
30.884*		A0 – A5	Si II
81.765	⊙, *	A0 – A5	Fe I, Cr II
4202.042	⊙	A3 – F2	Fe I
15.596	⊙, *	A0 – A5	Sr II, Cr II, Zr II
33.308	⊙, *	A0 – F2	Fe II, Fe I
50.506	⊙, *	A0 – A5	Fe I, bl.
54.348	⊙	F0 – F2	Cr I
71.532	⊙, *	A0 – F2	Fe I, bl.
4340.477	⊙	"	Hγ
4404.763	⊙	"	Fe I
15.137	⊙	"	Fe I
81.192	⊙, *	A0 – A5	Mg II, Fe II
4501.280	⊙	A5 – F2	Ti II
08.293	⊙	A0 – F2	Fe II
49.541	⊙, *a*	"	Fe II, Ti II

*The wave-length for Si II, which does not appear in the *Rowland Table*, is taken from the *Revised Multiplet Table*.

features which were constant in wave-length and found to be reliable over a considerable spectral range. Their wave-lengths were assigned arbitrarily to give agreement with the adopted control velocities. Such cases are few, being three out of a total of twenty-three lines.

The adopted wave-lengths are given in Table I which lists, in addition, the principal contributors to the blend and indicates in the third column how the wave-length was derived. The spectral range, over which the adopted wave-length is reliable, is given in the fourth column. When the symbol ⊙ appears alone the solar wave-lengths are combined as in the *Revised Rowland Table*. When ⊙ is accompanied by an asterisk it means that the solar wave-lengths were combined according to the relative intensities observed in the A stars. The letter *a* signifies that the wave-length was assigned arbitrarily on the basis of the velocities of the control stars.

The comparison of the radial velocities derived from the wave-lengths of Table I with the adopted control radial velocities allows one to conclude that the wave-lengths derived here are homogeneous to a high degree with those adopted for the F-K stars. The results are summarized in Table II. It is seen that the differences from

TABLE II. MEAN RESIDUALS FOR THE A STARS

Control Group	No. Stars	No. Plates	Mean Residual km./sec.
Taurus Cluster	4	24	−0.3 ±0.2
Coma Cluster	3	20	+0.7 ±0.3
Ursa Major Cluster	7	32	−0.7 ±0.5

the adopted cluster motions are small; the general mean residual from seventy-six spectra of fourteen stars is −0.2 km./sec. ±0.3.

The measured radial velocities of the A-type components of visual binaries agree sufficiently well with those of the solar-type companions. The component stars, because of orbital motion, will of course differ a little in radial velocity. Sixteen plates of three stars give a mean residual, in the sense A-type component *minus* Solar-type component, equal to −1.2 km./sec. ±1.5.

A further comparison is afforded with velocities determined with

high dispersion at the Lick Observatory for a considerable number of stars measured in the course of this program. Twenty-one stars (Victoria results based upon one hundred and twenty-one spectrograms) give a mean residual:

Victoria *minus* Lick = −0.1 km./sec. ±0.3.

The wave-lengths in Table I are hence considered to be satisfactory and upon the same system as those already derived for the solar-type stars which are based upon calculated velocities in the solar system. The values in Table I will be used henceforth in all high-dispersion results at Victoria, for the spectral classes A0 to F2, inclusive.

TABLE III. The Radial Velocities of Fifteen A Stars

Star H.D. No.		Type	Observed Velocity	Plates	Remarks
			km./sec.		
H.D. 25570		F2	+36.0 ±0.3	5	Tau. Cl.
27934	κ^1 *Tauri*	A3	+38.0 ±0.8	7	"
27962		A3s	+37.4 ±0.2	5	"
28546		F0	+38.8 ±0.5	7	"
40183	*β Aurigae*	A0	−18.6 ±0.6	7	U.Ma.Cl., Vis. Bin.
40312	*θAurigae A*	A1	+25.3 ±0.4	6	Vis. Bin.
48915	*Sirius*	A1	− 5.4 ±0.2	5	U.Ma.Cl., Vis. Bin.
50635A		A4n	+19.3 ±2.9	4	Vis. Bin.
107966		A2	+ 0.7 ±0.5	6	Coma Cl.
108382		A2	+ 0.8 ±0.3	7	"
108662		A0	− 0.3 ±0.6	7	"
118022	78 *Virginis*	A3	− 7.5 ±0.3	5	U.Ma.Cl.
137391	*μ Bootis A*	F0	−10.4 ±0.4	7	Vis. Bin.
209790	*ξCephei A*	A3	− 6.3 ±0.4	5	"
222603	*λPiscium*	A5	+10.9 ±0.7	6	U.Ma.Cl.

As a result of this study the radial velocities of fifteen stars have been determined and are given in Table III. The spectra are obtained with the II L spectrograph giving a linear dispersion, at Hγ, of 11.0 A./mm.

Dominion Astrophysical Observatory,
Victoria, B.C.
September 1, 1947.

REVIEWS OF PUBLICATIONS

Planetary Co-ordinates for the years 1940-1960, referred to the equinox of 1950.0. Prepared by H. M. Nautical Almanac Office, London W.C.2. Pp. xvi and 150, 9½ x 12 ins. Price 17s. 6d. net.

In 1939 this very useful publication was reviewed in this JOURNAL. In 1940 the type, plates and stock were destroyed. The Nautical Almanac Office has now supplied a photo-process reprint of this catalogue. The press work, paper and binding are all of high quality, so that the book is very easily used in computational work.

This volume is a continuation of the Planetary Co-ordinates for the years 1800-1940, published in 1933. For the planets Venus, Earth, Mars, Jupiter and Saturn at 10-day intervals, the heliocentric co-ordinates l and b, radius vector r, r^{-3}, heliocentric co-ordinates x, y, z, and attractions on the sun X, Y, Z. Extensive auxiliary tables are provided to facilitate computation of perturbations.

These tables are very useful either for the casual prediction of planetary phenomena or the intricate science of accurate computation of perturbations.

F. S. H.

Applied Architectural Acoustics, by Michael Rettinger. 208 pages, 5¼ x 8¼ in., 70 figures. Brooklyn, N.Y. Chemical Publishing Co. Inc., 1947. Price $5.50.

The present reviewer had the privilege of spending the year 1900-01 in research in the Jefferson Laboratory of Harvard University. Shortly before this an auditorium in a new building on the campus was found to be very unsatisfactory from an acoustical point of view and Prof. W. C. Sabine undertook to discover why. After elaborate experiments he published his results, which led to the birth of a new branch of science, namely, architectural acoustics. This has continually increased in importance, especially in recent years in connection with sound reproduction and in radio broadcasting.

The author of this book is of the engineering department of the Radio Corporation of America, and many difficult tasks have been set before him in the designing of rooms for various purposes in the

great broadcasting industry. The book is very practical, but the theoretical aspects of the subject have not been neglected. Indeed in attacking a problem the author usually writes down the mathematical equations relating to it and then proceeds to obtain a solution and give the result in concrete numbers. Among the subjects discussed are, reverberation, sound insulation, acoustic materials, broadcasting and television studios, hospitals, churches and auditoriums. The book is thoroughly scientific and will be of value to both students and engineers.

C. A. C.

Industrial Experimentation, by K. A. Brownlee. 151 pages, 5½ x 8¾ in. Brooklyn, N.Y., Chemical Publishing Co., Inc. 1947. Price $3.75.

In a laboratory investigation in physical science the experimenter usually has all the independent variables which enter into his problem under complete control, and he can estimate accurately the magnitude of the error to which his result is subject. But when the experimenting is on a large scale, as in a pilot plant in industry, or in some agricultural operations, in which complete control of all variables is practically impossible, much more elaborate methods must be followed in order to obtain a result which can be depended upon.

This book aims to supply a guide to modern statistical methods which are able to secure reliability in deductions from experimental data, and to the use of statistical design to attain maximum precision with minimum expenditure. It originates in the need of control of chemical processes in the manufacture of explosives in the Royal Ordnance Factories in England, and is a reprint (by permission) of a book published by the British Government. In its fifteen short chapters it gives explicit instructions for the application of the various appropriate formulas, but it does not attempt to develop the theoretical background. Where to look for this is provided in a list of works on statistics.

C. A. C.

OUT OF OLD BOOKS

By Helen Sawyer Hogg

The 1769 Transit of Venus, as seen from Canada

Of special interest to Canadians are early and little-known astronomical observations made at places which are now in Canada. These are observations of the transit of Venus in 1769.

As most of our readers know, transits of Venus across the disc of the sun occur in pairs eight years apart, with an interval alternately of 105 and 122 years between the pairs. The last transit of the seventeenth century was the one of 1639, made famous by Horrocks' prediction and observation. Before his untimely death, Horrocks seems to have developed the idea that transits of Venus could be used for the all-important determination of the distance of the sun from the earth, by the principles of trigonometric parallax. Halley later in the century developed this idea mathematically, and suggested, in a paper to the Royal Society in 1716, an all-out effort on the part of astronomers to observe carefully the next transit in 1761. Halley's article has been reprinted by R. A. Proctor in "Transits of Venus," London, 1882, from which we quote:

> There remains, then, the transit of Venus over the sun's disc; whose parallax, being almost as great as the solar parallax, will cause very sensible differences between the times in which Venus will seem to be passing over the sun at different parts of the earth. And from these differences, if they be observed as they ought, the sun's parallax may be determined even to a small part of a second. Nor do we require any other instrument for this purpose than common telescopes and clocks, only good of their kind; and in the observers nothing more is needful than fidelity, diligence, and a moderate skill in astronomy. For there is no need that the latitude of the place should be scrupulously observed, nor that the hours themselves should be accurately determined with respect to the meridian; it is sufficient that the clocks be regulated according to the motion of the heavens, if the times be well reckoned from the total ingress of Venus into the sun's disc to the beginning of her egress from it; that is, when the dark globe of Venus first begins to touch the bright limb of the sun within; which moments I know, by my own experience, may be observed within a second of time.
>
> But, on account of the very strict laws by which the motions of the planets are regulated, Venus is seldom seen with the sun's disc; and during the course of 120 years it could not be seen once—namely, from the year 1639 (when

this most pleasing sight happened to that excellent youth Horrocks, our countryman, and to him only since the Creation) to the year 1761, in which year, according to the theories which we have hitherto found agreeable to the celestial motions, Venus will again pass over the sun on May 26,[1] in the morning; so that at London about five o'clock in the morning we may expect to see it near the middle of the sun's disc, and not above four minutes of a degree south of the sun's centre. But the duration of this transit will be almost eight hours —namely, from two o'clock in the morning till almost ten. Hence the ingress will not be visible in England; but as the sun will at that time be in the sixteenth degree of Gemini, having almost twenty-three degrees north declination, it will be seen without setting at all, in almost all parts of the north frigid zone; and therefore the inhabitants of the north coast of Norway, beyond the city of Nidrosia, which is called Drontheim, as far as the North Cape, will be able to observe Venus entering the sun's disc; and perhaps the ingress of Venus upon the sun when rising will be seen by the Scotch, in the northern parts of the kingdom, and by the inhabitants of the Shetland Isles, commonly called Thule. But at the time when Venus will be nearest the sun's centre the sun will be vertical to the northern shores of the Bay of Bengal, or rather over the kingdom of Pegu; and therefore in the adjacent regions, as the sun, when Venus enters his disc, will be almost four hours towards the east, and as many towards the west at the time of her egress, the apparent motion of Venus on the sun will be accelerated by almost double the horizontal parallax of Venus from the sun; because Venus at that time is carried with a retrograde motion from east to west, while an eye placed upon the earth's surface is whirled the contrary way, from east to west. And from this shortening of the time only we might safely enough draw a conclusion concerning the parallax which we are in search of, provided the diameter of the sun and the latitude of Venus were accurately known. But we cannot expect an exact computation in a matter of such subtility.

We must endeavour, therefore, to obtain if possible another observation, to be taken in those places where Venus will be in the middle of the sun's disc at midnight; that is, in places under the opposite meridian to the former, or about six hours or ninety degrees west of London, and where Venus enters upon the sun a little before its setting, and goes off a little after its rising. And this will happen under the above-mentioned meridian, and where the elevation of the north pole is about fifty-six degrees; that is, in a part of Hudson's Bay near a place called Port Nelson. For, in this and the adjacent places, the parallax of Venus will increase the duration of the transit by at least six minutes of time.

If therefore it should happen that this transit should be properly observed by skilful persons at both these places, it is clear that its duration will be seventeen minutes longer as seen from Port Nelson, than as seen from the East Indies. Nor is it of much consequence (if the English shall at that time

[1] June 6, according to new style.

give any attention to this affair) whether the observation be made at Fort George, commonly called Madras, or at Bencoolen, on the western shore of the island of Sumatra, near the equator. But if the French should be disposed to take any pains herein, an observer may station himself conveniently enough at Pondicherry, on the west shore of the Bay of Bengal, where the altitude of the pole is about twelve degrees. As to the Dutch, their celebrated mart at Batavia will afford them a place of observation fit enough for the purpose, provided they also have but a disposition to assist in advancing, in this particular, the knowledge of the heavens. And indeed I could wish that many observations of this famed phenomenon might be taken by different persons at separate places, both that we might arrive at a greater degree of certainty by their agreement, and also lest any single observer should be deprived by the intervention of clouds of a sight which I know not whether any man living in this or the next age will ever see again; and on which depends the certain and adequate solution of a problem the most noble, and at any other time not to be attained to. I recommend it therefore again and again to those curious astronomers who (when I am dead) will have an opportunity of observing these things, that they will remember this my admonition, and diligently apply themselves with all their might in making this observation, and I earnestly wish them all imaginable success: in the first place, that they may not by the unseasonable obscurity of a cloudy sky be deprived of this most desirable sight, and then, that having ascertained with more exactness the magnitudes of the planetary orbits, it may redound to their immortal fame and glory.

This appeal of Halley for observations did not fall upon deaf ears, for certainly a huge amount of energy and preparation went into the observation of the transits of 1761 and 1769. That of 1761 was observed by 176 persons at 117 stations in various sections of the world. Lengthy voyages of great hardship and inconvenience were undertaken, among which we might mention that of Chappe d'Anteroche to Tobolsk in Siberia and that of Le Gentil which probably constituted the most picturesque adventure of all. We quote the description of Sir David Gill in the introduction he wrote to his wife's book, "Six Months in Ascension."

The French sent Pingré to the Island of Rodriguez, and Le Gentil should have observed at Pondicherry.

Poor Le Gentil! He duly reached Mauritius on the 10th of July, 1760,—nearly a year before the Transit. War having meanwhile broken out between France and England, he was unable to reach Pondicherry; so he resolved to go to the Island of Rodriguez instead, to join Pingré, who was already there. When on the point of starting for Rodriguez, he learned that a French frigate was about to sail from Mauritius for the coast of Coromandel. Le Gentil decided to avail himself of the opportunity thus offered to reach the point chosen

by the Academy; but one delay after another occurred, and it was not until the middle of March that he sailed again from Mauritius. There was not much time to be lost, for the Transit would occur on the 6th of June. Detained by frequent calms he did not reach the coast of Malabar till the 24th of May. Still there might have been enough time to prepare for the observation, had not the commander of the frigate learned that the English were masters of Mahe and Pondicherry. His only chance to escape capture was to make off as quickly as possible. This he did; steering a course for Mauritius again, to Le Gentil's utmost despair.

The 6th of June arrived. The sky was gloriously clear. From the deck of the vessel Le Gentil made the best observations he could; but, from so unsteady a platform, they could be of little value to science. . . .

But the failure of the Transit of 1761 only urged to new effort for that of 1769. Astronomers through the world felt that if the opportunity, which would then occur, was lost, another so favourable for determining the Sun's Distance would not occur again for 105 years. . . .

The French astronomer, Le Gentil, . . . had no sooner returned to Mauritius than he set out again for Pondicherry, determined to wait there, for eight years, till the next Transit of Venus.

The eventful 3rd of June, 1769, at last arrived.

The morning was fine, and everything promised a happy issue. But, just as the critical moment approached, an unfortunate cloud eclipsed the Sun, a torrent of rain descended, and the fruit of eight years' waiting was lost. Le Gentil had profitably employed his time in studying the astronomy of the Brahmins, so his eight years in Pondicherry had been well occupied; but the agony of disappointment he must have felt at the defeat of his noble endeavours cannot but enlist the sympathy of all who know his story.

The results of the transit of 1761 proved somewhat disappointing in that Venus at the moment of contact, instead of appearing circular, assumed a peculiar shape "like a ninepin". This is the familiar phenomenon of the "black drop".

Immediately after the transit, however, preparations were started for the observation of the next transit in 1769 on a wide scale. This transit was observed in many parts of the world, and values of the solar parallax were derived from it which are in good agreement with our present ideas of 8".8. About four hundred memoirs on the subject were sent to the different learned bodies of Europe. It is small wonder then that the observations made from what is now Canada are so little known to-day, buried as they are in a multitude of observations.

The volume of the *Philosophical Transactions* of the Royal Society which prints them, vol. LIX, 1769, and which I have borrowed from McGill University, contains twenty-eight papers on this transit,

signed by many famous names such as Hornsby, Rittenhouse, Wargentin, Winthrop, De la Lande, Jeremiah Dixon, Messier, Wollaston, Biddle, and Benjamin Franklin.

The most noteworthy of the Canadian observations is by Wales and Dymond from the northwest shore of Hudson's Bay. Since the actual observations have long since been utilized in the reductions of the transit, we print merely the remarks as written by these observers, including their comments that the appearance of Venus at contact might be caused by an atmosphere around it. The paper gives absolutely no reference to the experiences of these two observers as they journeyed from England to that desolate coast. Gill says (op. cit., p. xvi),

> Another English expedition was sent to Hudson's Bay. There Dymock [correctly, Dymond] and Wales, after encountering a good many hardships, successfully observed the Transit; and their observations acquired a special value.

Where the account of their hardships may be found, I do not know. Maybe some of our readers can supply the information. The telescope they used was two feet long, magnifying 120 times, and their north latitude was 58° 47′ 32″.

Astronomical Observations made by Order of the Royal Society, *at* Prince of Wales Fort, *on the North-West Coast of* Hudson's Bay. *By* William Wales *and* Joseph Dymond.

REMARKS:

1. All the measurements of Venus's diameter; and also all those of the Sun, which are not said to be horizontal, were taken with the micrometer, in the same direction that the last preceding distance of the limbs of Venus and the Sun was measured with.
2. We were obliged to alter the rack-work of the micrometer before we began to measure any distances of the limbs, etc., in order to make it take in the diameter of Venus, off the scale.
3. The heavens at the beginning, and for a considerable time both before and after, were frequently obscured by clouds: but in the intervals, the air was very clear, and the Sun's limb extreamely well defined.
4. Soon after Venus was half immerged, a bright crescent, or rim of light, encompassed all that part of her circumference which was off the Sun; thereby rendering her whole periphery visible. This continued very bright until within a few minutes of the internal contact, and then vanished away gradually.
5. We took for the instant of the first internal contact, the time when the least visible thread of light appeared behind the subsequent limb of Venus: but before that time, Venus's limb seemed within that of the Sun, and his limbs appeared

behind hers in two very obtuse points, seeming as if they would run together in a broad stream, like two drops of oil; but which nevertheless did not happen, but joined in a very fine thread, at some distance from the exterior limb of Venus. This appearance was much more considerable at the egress than at the ingress; owing, as we apprehend, to the bad state of the air at that time. We took for the instant of internal contact at the egress, the time when the thread of light disappeared before the preceeding limb of the planet, from which time W. W. took notice that he had told about 24″ when the limbs of the Sun and Venus were apparently in contact: a circumstance which he did not venture to attend to at the ingress.

6. We saw nothing like the appearance of an atmosphere around Venus (unless the above-mentioned phaenomena may be thought to proceed from thence) either at the beginning, end, or during the time of the transit: nor could we see anything of a satellite; though we looked for it several times.

7. It may not be improper to add, that the haziness, complained of at the egress, was not owing to any accidental bad quality of the air at that time; it is continually so here to 10° or 12° above the horizon, and often even to 16° or 18,° in what may be called the clearest state of the heavens.

The floor of the Observatory might be above 50 Feet above the level of the Sea at Low-water Mark.

Another observation in Canada was made near Quebec, by Thomas Wright, and Captain Holland, and Mr. St. Germain of the Seminary of Quebec (the precursor of Laval University).

An account of an observation of the Transit of Venus, made at Isle Coudre near Quebec. In a letter to the Reverend Nevil Maskelyne, Astronomer Royal, from Mr. Thomas Wright, Deputy Surveyor of the Northern District of America.

Quebec, June 15, 1769.

Sir,

I was prevented landing at the bay of Gaspée, as I purposed (by blowing, thick weather); but, however, I had the good fortune to reach the Island of Coudre, where I landed, with all my apparatus, the 30th of May; and took up my abode at a house well situated, in every respect, for my purpose. The next morning I had a carpenter, who fixed my clock, very firm and perpendicular, against a beam of the house. I immediately set it a-going by my watch, which had not been set to true time for almost a fortnight; but, however, I doubt not but that the following observations of corresponding altitudes will shew exactly the time, as also the regular rate of going of the clock, which I did not venture to adjust, my time being short.

As it is likely I may stay here some time, and all next winter, I shall endeavour to make such observations as may be useful in further settling the longitude here.

Captain Holland observed the external contact, but not the internal, being prevented by clouds. He has sent them to you by this opportunity.

I am, SIR, Your most obedient, humble servant,

THO. WRIGHT.

Saturday, June 3, the morning cloudy, no altitudes taken. At 2^h $49'$ $22''$ by the clock, I happened to take my eye off from the very point where I afterwards found the external contact happened, imagining I saw it something more to westward; but finding my mistake, I returned to the former point, where I found Venus had made a very

2 50 25 small impression at 2^h $50'$ $25''$, as is set down in the margin.

3 07 48 time when Venus appeared compleatly round to the eye, and to appearance rather detached, and joined by a small dark thread or ligament, which prevented the rays of light from appearing.

3 08 19 time when the rays of light just appeared, at the internal contact. By means of two oblong smoaked glasses with different shades, made to slide in a groove fixed to my telescope, the phaenomenon appeared very distinct and pleasing to the eye, notwithstanding the weather was a little hazy, and very much so, near the horizon. The thermometer stood at 74 degrees at the time of observation, and the weather was remarkably close and sultry two days before, and quite calm till an hour before the transit happened, when it began to blow very fresh. June 4, the weather continued much the same, and about 9^h $30'$ in the evening, we had a shock of an earthquake, which lasted about four seconds, and alarmed all the inhabitants of the island.

The weather, at the time of the transit, was not clear enough to observe the least appearance of an atmosphere round the planet, supposing there really had been one.

Remarks by the ASTRONOMER ROYAL.

The instruments made use of by Mr. Wright, in the foregoing observations, were a 2 feet reflecting telescope; a pendulum clock beating half seconds; a brass Hadley's sextant, of about 15 inches radius; and a rectangular reservoir for holding quick silver, or any other fluid, which is sheltered from the wind by two glass sides inclined to one another, and ground truly plane: this last for taking the Sun's double altitude by reflection with the Hadley's sextant. . . . The place of observation is $35'$ $41''$ north of Quebec, and $31'$ $34''$ east of it.

Astronomical Observations made by Samuel Holland, Esquire, Surveyor- General of Lands for the Northern District of North-America and others of his Party. Communicated by the Astronomer Royal.

March 8, 1769, observed by Samuel Holland, Esquire, at his house, bearing south, 56° west from Quebec, distance from the castle of St. Lewis 2½ miles, with Bird's astronomical quadrant, the latitude, viz. . . .

Mean result of latitude observations, 46° $47'$ $15''$.

June 3, 1769, observed, by the same, at the same place, with the same instrument, the Transit of Venus, as follows: at 2 hours, 28 minutes, and 1½ seconds, perceived a luminous point on the lower part of the Sun's limb, by appearance; and, in the same place, 1½ seconds afterwards, the first external contact was formed, which rectified as the clock or time-piece of Graham was 15 seconds too fast at the time of observation (as proved by equal altitudes of the Sun taken with Bird's astronomical quadrant on the 1st, 2nd, 4th, and 5th instant) the equal or mean time of observing the first external contact will be at 2 hours, 27 minutes, and 48 seconds. Mr. St. Germain, of the seminary of Quebec, observed the same contact, at the same instant, with Short's 2 feet reflecting telescope. Clouds intervening, prevented the observation of the first internal contact; but at 6 o'clock the Planet might be seen with the naked eye on the Sun's disc, through the haziness of the atmosphere.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

The Sun-spot Cycle

As most of our readers know, there have been many spots on the sun during the past year, among them being probably the largest spot ever recorded. In the HANDBOOK for 1947 (p. 24) Mr. De Lisle Garneau of Montreal estimated that the maximum for the present cycle would be reached about 1948.0. The dates of the seven next preceding maxima are given by Brunner as

1870.6, 1883.9, 1894.1, 1907.0, 1917.6, 1928.4, 1937.4;

and by subtracting each number from that following it, the lengths of the cycles are found to be

13.3, 10.2, 12.9, 10.6, 10.8, 9.0, (10.6) years.

In the following table Mr. Garneau gives the results of his observations for the ten months January to October 1947.

	No. of Obs.	*Total Groups*	*Total Spots*		*No. of Obs.*	*Total Groups*	*Total Spots*
Jan.	10	78	555	June	24	228	1802
Feb.	14	115	1142	July	20	170	1009
Mar.	18	132	1276	Aug.	26	265	3067
Apr.	18	141	1406	Sept.	23	211	2045
May	19	191	1877	Oct.	17	160	1339

The columns give the number of observations, the total groups and the total spots observed.

May was the most active month, and the first two weeks of August the most active period of the ten months.

C. A. C.

Don't Need to Know Any More

Three of the proper names in the following letter have been changed, otherwise it is exactly as received.

July, 1947.

Dr. C. A. Chant,
Toronto, Ont.

Dear Sir;—

I received your letter in answer to mine on which I asked you a few questions. You asked me to write again but I guess I don't need to know any more. I wish to take this opportunity to—

Thank You Very Much,
John Smith,
R.R. No. 7,
Looloo, Ontario.

Wrote by
Mary Graceful
Don't let me know you got this Letter

MEETINGS OF THE SOCIETY

AT EDMONTON

April 10, 1947.—The main paper of the evening was given by Dr. D. B. Scott, on "The Glass Giant of Palomar." "The Glass Giant of Palomar" is a book by David Woodbury. It is a story for the layman about the problems encountered, and solved in one way or another during the planning and production of the 200-inch telescope.

The astronomer Hale was able to persuade the Carnegie Foundation of the need for such a telescope. The Foundation finally agreed to give six million dollars for the project.

To avoid the troubles with glass due to temperature changes, an attempt was made to cast a quartz disc. This had to be abandoned after 600,000 dollars had been spent. The next trials were with Pyrex, and a perfect disc with honeycomb back was finally obtained.

A flood came near to ruining the disc during the 10-month annealing process. A special car on a special train travelling a carefully selected route took the disc to the optical shop in Pasadena.

The grinding and polishing took several years, and were interrupted by World War II. The final figuring and testing is now being completed. The housing and mounting are ready, and before long the new telescope should be bringing the world information from the farthest depths of space.

May 8, 1947.—The main paper was given by Mr. Alec Stockwell on "Tycho Brahe." Dec. 14, 1946, was the 400th anniversary of his birth. He was the son of a Danish nobleman, and was brought up by an uncle. Tycho disagreed with Copernicus' theory of the Universe and started taking observations of the positions of the planets and the moon. He hoped to obtain evidence supporting a theory of his own. He made use of the best instruments and methods and achieved remarkable accuracy over a long period of time.

These observations, ironically enough, enabled Kepler to confirm the ideas of Copernicus, and to enunciate the famous three laws, which were in turn used by Newton in developing his theory of gravitation.

E. H. GOWAN, *Hon. Secretary.*

AT VICTORIA

January 9, 1946.—In calling the meeting to order, the President drew the attention of members to the planets that would be visible during the coming month.

In a five-minute talk Mr. Pope outlined the methods by which the distances to celestial objects are measured. The President introduced the speakers of the evening, Mr. R. Peters and Mrs. P. Noble, their subjects being the biographies of the outstanding astronomers, Sir Isaac Newton and Sir Arthur Eddington.

The character, environment in youth and salient achievements of each astronomer were well portrayed by the respective speakers.

Lt. Cdr. Scaife expressed the appreciation of those present to the speakers for their addresses.

February 13, 1946.—Mr. R. Peters gave a brief talk on the first magnitude stars visible at this time, and Mr. W. Hobday outlined the course for instruction in the operation of the Wray telescope, to commence on February 25th.

In his address on "Volcanoes and Volcanism," Dr. J. S. Stevenson, F.C.G.S., of the B.C. Department of Mines, described the familiar volcanic rocks and described the various forms of volcanic activity. The formation of some of the most famous volcanoes was described, and illustrated with sketches and photographs. The history of Mount Vesuvius was traced from the eruption described by Pliny, 79 A.D. to the recent outpourings of lava in 1944. The world's most recent volcano, Paricutin, in Mexico, was also described, from its birth in 1943 to the present time, when it is still erupting. In July of this last summer, several scientists took part in helicopter flights over Paricutin, Sikorsky, the inventor of the helicopter, being an active participant. The speaker noted the contrast to the status of vulcanology a few centuries ago, when volcanoes were objects of superstition and quite properly held in awe.

The appreciation of the members to Dr. Stevenson for his very excellent address was expressed by Dr. McKellar.

March 13, 1946.—Two five-minute talks were given at the beginning of the meeting, the first by Mr. Terry Scaife on the principal features of the spectroscope and its uses, and the second by Mr. Harold Reid outlining the methods by which celestial bodies are weighed.

Mr. R. Peters took the occasion to thank the members of the Centre for their support in his election to the General Council.

Dr. Andrew McKellar, in the course of his address on "Atomic Energy," outlined the history of the research work accomplished in this field, mentioning the scientists associated with it. Dr. McKellar stated that the original theory of the indestructibility of the atom had been disproved by this research, and went on to describe the structure of the atom and the release of its energy. Possibilities in the commercial use of atomic energy were indicated and in conclusion Dr. McKellar stressed the necessity of control in releasing information on the results obtained from research in this field.

Dr. Beals expressed the thanks of those present for the instructive address.

April 10, 1946.—For this meeting the members were the guests of the Royal Canadian Naval College at Royal Roads, and enjoyed an interesting and instructive demonstration of the planetarium.

October 9, 1946.—At the time of the commencement of this meeting a spectacular meteor shower was taking place under very ideal conditions of illumina-

tion. Dr. Wright spoke briefly on the phenomenon, pointing out the close proximity of the Comet Giacobini-Zinner to the earth at this time.

The speaker for the evening was Mr. R. E. G. Langton, whose talk dealt with cosmic rays. Mr. Langton explained that the origin of cosmic rays was probably outside the earth's atmosphere and that these rays had great penetrating powers. It required, he said, a wall of lead some seventy-five feet thick to eliminate them. Experiments with the electroscope, upon being sent up to the stratosphere, gave us the first information about cosmic rays. Wilson's cloud chamber was described as an instrument to show the path of these electrically charged particles, and allowed the scientist to evaluate the speed and direction, weight and collision effects. In closing his lecture, Mr. Langton gave a few of the theories of the origin of the cosmic rays.

The thanks of the audience was expressed by Mr. Hughes.

November 13, 1946.—The Victoria Centre members were the guests of Commander Ogle at the Royal Naval College, where he described for them various non-astronomically based methods of navigation, namely radar for short range navigation and loran for long range navigation. This was followed by three films which explained in great detail the mathematical basis for astronomical navigation.

Mr. Robert Peters thanked Commander Ogle on behalf of the Society and the meeting adjourned at 10 p.m.

December 11, 1946.—The annual dinner of the Centre was held in the Strathcona Hotel, with ninety members and friends present. Following the dinner, the following reports were read: President's Report, Dr. Wright; Librarian's Report, Miss Y. Langworthy; Secretary-Treasurer's Reports, Miss J. K. McDonald. The annual election of officers was carried out and the results reported to the meeting.

Dr. J. A. Pearce, Director of the Dominion Astrophysical Observatory, was the speaker of the evening, and his topic was entitled "Exploring the Atmosphere." In a general survey he described the troposphere, the lower atmosphere, the stratosphere which extends from about five miles up, and the ionosphere layers of ionized particles many kilometres above the earth's surface. He described the variations of temperature and pressure throughout the atmosphere, and the different physical conditions existing. In concluding his address he made reference to some very recent developments in the study of the upper atmosphere, including the study of meteors insofar as they relate to the temperature and pressure of the atmosphere at heights of fifty miles or more, and also to the information gained concerning the ozone layer from data secured in V-2 rocket flight tests.

Dr. R. M. Petrie expressed to Dr. Pearce the appreciation of the audience.

G. L. DARIMONT, *Recorder.*

AT WINNIPEG

January 8, 1947.—A regular meeting was held at 8.15 p.m. in Theatre B, University of Manitoba. Mr. D. R. P. Coats was in the chair. Miss E. A. P. Fraser was proposed for membership.

Our Honorary President, Dr. L. A. H. Warren, gave the lecture. His subject was "The Fundamentals of Astronomy." Before beginning the lecture Dr. Warren moved that the Winnipeg Centre extend its hearty congratulations to Dr. Campbell, former Winnipeg member, on the occasion of his election as President of the R.A.S.C.

Dr. Warren illustrated his lecture with slides and explained many of the tables and data in the HANDBOOK. He showed the audience how to use it to find clusters, nebulae and doubles in the sky with the aid of small telescopes. He explained how radial velocities are measured by the red and violet shift in the spectra and how spectroscopic binaries show up in the spectroscope. Dr. Warren illustrated the reasons for the apparent movement of the planets in the sky by slides which showed the relative positions of planets as we see them from the earth. The significance of the parallax of stars was explained and the speaker showed how the absolute magnitude of a star can be obtained if its apparent magnitude and its parallax are known by a simple formula.

The lecture was concluded by a series of slides showing some of the most beautiful doubles which can be seen in small telescopes.

February 5, 1947.—The president, Mr. D. R. P. Coats, expressed the sorrow felt by this Centre at the death of Prof. Anderson, who has given us much of his time and many excellent lectures.

Mr. L. W. Koser gave a short illustrated talk on "Astronomy in the News." He gave a brief description of a method recently developed for ascertaining latitude.

The main lecture was given by Mr. D. M. Robertson, Meteorologist-in-charge at the Airways Meteorological Service. His subject was "Modern Weather Forecasting." The lecture was illustrated by weather maps and other data. A motion picture of a typical storm with its causes was shown. The speaker gave a history of weather forecasting. In the 17th century, pressure and temperature instruments were used to forecast weather changes. In 1860 reports were collected by telegraph. In 1873 Canada began a meteorological service, using telegraph to collect weather reports. In 1925 observations of weather conditions were relayed to meteorological offices by radio. At the present time there are 900 weather stations operating in Canada, United States and Alaska. The Canadian Airways Meteorological Service now has its own teletype system connecting all points between Newfoundland and Victoria. The reports reaching a station are plotted on maps by coding and every six hours a new map is made. The map when complete gives the officer a picture of the weather conditions existing over the continent, and by reference to maps 6 hours and 12 hours before he can foresee with considerable accuracy the conditions which will exist 6 to 24 hours ahead. The maps have contoured lines which run through all points having the same pressure. These lines are known as pressure lines. Air masses flow along what is known as ice bars, the rate depending on the pressure areas and precipitation and clouds in areas of low pressure. This is not always the case however. In 1914 to 1918 a new theory originated which in part suggested that the conditions existing in the upper layers of air determined the weather in the lower atmos-

phere. The changes in weather are caused by the movement of air masses. The air mass which is stagnant in the far north of North America is called the Polar Continental. The air mass over the north Atlantic is called the Polar Atlantic. That over the north Pacific is called the Polar Pacific; that over the south Pacific is called the Tropical Pacific and that over the Gulf of Mexico is called the Tropical Gulf air mass. These air masses move across the continent and affect the temperatures and weather. The boundaries between the air masses are called fronts and are usually oblique to the vertical. The warm air rises up the inclined fronts to form clouds and precipitation. The formation of clouds and their characteristics are an indication to the meteorologist of their height and the condition which caused them.

The type of clouds is the chief observation which the weather stations must report. Hydrogen balloons are released and watched by telescopes to ascertain air currents and in some cases an instrument called a radio-sonde is released which rises into the stratosphere and automatically transmits the weather conditions to the ground station.

The inaccuracy of forecasts when it exists is usually caused by the change in the properties of an air mass between an observation period and the time of the forecast.

The President thanked the speaker on behalf of the meeting and a short period of discussion followed. The following new members were voted into the Winnipeg Centre: Miss Frazer, Mr. Wm. Begge, Miss Beverley Sharman, Mr. Wm. Cameron, Mrs. C. D. Card and Mr. Norman Light.

C. D. CARD, *Secretary.*

AT TORONTO

February 11, 1947.—The meeting was in the McLennan Laboratory, the president, Dr. J. F. Heard, in the chair.

Mr. Collins paid a warm tribute to the late Mr. A. F. Miller, who was a charter member and a past president of the Society.

Dr. A. Vibert Douglas, of Queen's University, gave the address of the evening. It dealt with her trip to London and Zurich on her way to the Students' Christian Federation Conference at Geneva in the spring of 1946.

In the midst of war's destruction, oppressions, deprivations and fears in those regions, even in the universities, she found that scientific research had been kept up to some extent in all centres and to an encouraging degree in some. In Amsterdam researches in fungi continued, and the end of the war found a complete up-to-date museum of fungi and fungi-culture. At Zurich, Dr. Bossart, the sun-spot expert, had kept up a keen and successful study in this field. At Leiden, Dr. Oort continued his work on interstellar space and was selected to give the Darwin lectures at the Royal Society meetings in London in 1946. These gave a fine view of the nature and behaviour of interstellar material, and a stimulating foundation for the consideration of the nature of primordial matter and the origin of worlds.

Dr. H. H. Plaskett, son of our former Victoria Observatory director, warmly complimented Dr. Oort on his original, constructive, and stimulating discourses. He also urged the building of a new British Observatory to replace that of old Greenwich, now entirely surrounded by smoky London; already a new site has been chosen in Sussex for a new station to be called "The Isaac Newton Observatory."

February 25, 1947.—New members elected were: F. C. Clubb, Mrs. W. G. Allen, Dorothy Allen, Jas. MacDonald.

Dr. S. H. Gould, Professor of Classics in Victoria College, gave an address on "Gulliver and the Moons of Mars," with the purpose of showing, in part, the connection of studies in science and the humanities.

After outlining the ways by which Swift sought to poke good-natured fun at the scientists of his day, the lecturer described the well-known riddle of the Moons of Mars, and how Swift had described, with a striking degree of correctness, the orbits of two satellites of Mars which were not discovered by an astronomer until 150 more years had passed. Was this pure coincidence, or had Swift enough actual or theoretical knowledge to prompt his conclusions? Dr. Gould showed that in one respect at least Swift must have made a happy guess and had not delved into Newton's *Principia* as deeply as he might. Swift's orbits for the two satellites called for an absurd value for the density of Mars, according to the calculations quoted by Dr. Gould.

March 11, 1947.—Dr. Ching Sung Yu was elected to membership.

Mr. F. K. Dalton referred to a letter received from the Girl Guides' Association requesting the aid of instructors and examiners in their Astronomy Badge course. A number of our members volunteered for this work.

Miss R. J. Northcott spoke on the HANDBOOK notes for this month, reminding us of the times for observing the minima of Algol, and Dr. J. F. Heard, the chairman, spoke of the great display of sun-spots this winter, some being large enough to see with the naked eye.

Dr. R. E. Williamson, of the Dunlap Observatory, addressed the meeting on the Proceedings of the 1946 meetings of the American Association of Astronomers, which he attended. A leading event of those meetings was the demonstrations and discussions of studies of the sun and of matter in distant spaces, by means of spectrograms obtained with rockets sent up as high as 60 miles where the air is so rare that there is little interference with the rays from the sun. Also, striking results were obtained by taking, at great altitudes and at considerable intervals (as much as 10 minutes in some cases), a series of pictures of solar prominences, then putting them together in series, and reeling them off to give a fairly rapid movie film of the behaviour of these active prominences.

The resulting spectacular picture showed vividly their strange behaviour, often quite unlike an ordinary visible flame; at times they licked outward in strange forms and actions, at times some seemed to originate at a distance from the sun and then move into it, whilst still others seemed to grow to maximum length and then back into the sun again. The inference is that the whole range

of radiations was emitted, our light rays, of course, being only a small portion. Hence other instruments than our cameras are needed to give a full picture. To test this, a radio-type was tried. It gave different results when pointed to the sun, and to different parts of the Milky Way. So it seems that a battery of cameras, one for each type of radiation (for vision, for radar, radio, etc.), is needed to show the whole picture of what is happening at the sun and what things are causing it. Numbers of details have already appeared; for example, in interstellar space hydrogen is most abundant (about one atom per cu. cm.), and sodium, oxygen, nitrogen considerably less; in those spaces the temperature is so low that atoms do not unite and so when atoms collide they just stick together like bits of moist soil; particles of elements closely associated in other conditions (e.g., liquid air) fly apart in these cold interstellar spaces; between the galaxies nothing apparently exists.

March 25, 1947.—Mr. Andrew Thomson, Controller of the Meteorological Service of Canada, gave the lecture of the evening, on "Advances in Meteorology Services during the War." He first traced the course of the very low pressure area which was giving us on this day the greatest wind storm experienced here for many years. He pointed out that thus far weather predictions for a given locality can be certain only for a day or two in advance.

Little advance in fundamental ideas concerning meteorology was made during the war but a very great increase in the successful use of ways and means known previously or devised as war measures was made. In 1939 the first step taken was to withdraw all weather broadcasting and public reports, and to set about organizing and harmonizing all the weather-study activities of the Allies; their secret transmission codes, and means and methods for co-operation in their widespread war operations; and whilst shutting off access to these by the enemy, to gain access to their activities in these fields. Almost at the beginning a German vessel equipped as a floating weather bureau station was surprised and captured in a Greenland fiord. In all these efforts special emphasis was placed on the techniques of weather forecasting and of data transmission, and the speaker thought that this would lead to important advances in permanent technical and legal set-ups for use by all nations. Steps are already being taken and an international conference on it is to be held in Toronto in 1947.

The Atlantic war theatre made special demands on weather departments. A series of courses for aeroplanes to cover the whole area was mapped out (by Britain, Canada and U.S.A., chiefly), and planes equipped for obtaining atmosphere data patrolled them regularly and so supplied information for all navigation and war-planning. Later, vessels equipped as floating weather bureau stations were provided and the plan now is to increase these over the Atlantic as a permanent force. At the same time experiments were carried on around the coasts and the great lakes of Canada to develop further the means for recording and transmitting atmosphere data. Automatic devices now record and transmit to considerable distances, hourly, (for example) air and water temperatures. Hence in addition to the usual telephone and telegraph, there are these robot stations so promising for our northern shores, and also automatic teletype and other radar

applications which can be used to transmit print-pictures as well as a variety of others such as cloud pictures, all of which are of immense help to navigators, aeroplane people in particular.

April 8, 1947.—The main feature of the meeting was a showing of the following movie films of aesthetic and scientific interest.

1. "Curves of Colour"—a talkie showing many beautiful displays of colour pictures from nature and from man's devices; and also showing something of the origin and cause of colour and of scientific analyses of it.

2. "Excursions in Science—Thunderbolt Hunting," showing methods of studying lightning and thunder, thereby revealing its action, results and guarding against it. The double action of lightning—down to the object and then back to the clouds with the latter action proving to be the most destructive phase, were made very clear.

3. A film showing scenes in the Western States, including the Palomar Observatory—its construction and grinding of the mirror.

4. "Excursions in Science—the phototube or electric eye." This is an important instrument for investigating and using light, the most important after the spectroscope.

5. "Television"—showing it as an application of the phototube. A very large number of minute electric eyes are used to transmit the pattern of light and shade given by the object over a distance where the same pattern may be thrown on a screen.

6. Colour film of views by Mr. Singer.

7. A film of the formal opening of Dunlap Observatory, May 31, 1935.

J. R. Tuck, *Recorder*.

The Royal Astronomical Society of Canada

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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

1890-1946

The Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal and Quebec, P.Q.; Ottawa, Toronto, Hamilton, London and Windsor, Ontario; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C. As well as nearly 1,200 members of these Canadian Centres, there are over 400 members not attached to any Centre, mostly resident in other nations, while some 50 additional institutions or persons subscribe to our publications.

The Society publishes a monthly "Journal" containing about 500 pages and a yearly "Observer's Handbook" of 80 pages. Single copies of the "Journal" or "Handbook" are 25 cents, postpaid. In quantities of 10 or more copies, the price is 20 cents a copy.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are sent free to all members or may be subscribed for separately. Applications for membership or publications may be made to the General Secretary, 3 Willcocks St., Toronto.

The Society has for Sale:

Reprinted from the "Journal" of the Royal Astronomical Society, 1936-1944.

The Physical State of the Upper Atmosphere, (revised 1941) by B. Haurwitz, 96 pages; Price 75 cents postpaid.

General Instruction for Meteor Observing, (revised 1940) by Peter M. Millman, 24 pages; Price 15 cents postpaid.

A Yoke Mounting for the Six-inch Telescope, by H. Boyd Brydon, 8 pages; Price 10 cents postpaid.

Setting Up and Adjusting the Equatorial Reflecting Telescope, by H. Boyd Brydon, 25 pages; Price 25 cents postpaid.

Occultations: their Prediction, Observation and Reduction, by H. Boyd Brydon, 76 pages, 1944; Price 60 cents.

In quantities of ten or more copies, a discount of 20 per cent will be allowed. Send Money Order to 3 Willcocks St., Toronto.

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